



Product Development of Ready-to-Drink Cocoa Powder Incorporated with Chili Powder

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Abstract

Cocoa and chili are important economic plants with important bioactive compounds that are beneficial to the body and are suitable for development into health drinks. This research aimed to study the appropriate amount of chili powder in ready-to-drink cocoa powder products for the optimal physical, chemical, microbiological and sensory characteristics that are acceptable to consumers by using chili powder at 0.0, 0.1, 0.2, and 0.3%. It was found that the ready-to-drink chili powder cocoa beverage with 0.3% chili powder had the highest brightness (L^*), redness ($+a^*$) and yellowness ($+b^*$) values, which were 27.60, 44.11 and 37.13, respectively. The highest value of total soluble solid (control) or 0.0% of chili powder was 25°Brix. The total acidity percentages using the amounts of chili powder at 0.1, 0.2 and 0.3% were not significantly different ($p>0.05$). The water solubility value using the amounts of chili powder 0.3% had the highest value of 7.92%, which was the most soluble solid due to low moisture content. The moisture content and fat content using the amount of chili powder 0.3% had the lowest values of 4.10 and 1.13%, respectively, which meant that the product was dry and had low fat content. The microbiological analysis results did not find bacteria exceeding the standard criteria in all treatments. The sensory quality of the amount of chili powder that was acceptable less than the control treatment from the panelists found that the taste and overall fondness of the treatment using 0.1% had higher fondness scores than using 0.2 and 0.3% chili powder, indicating that 0.1% was the most appropriate amount and accepted by consumers. The food industry could use the data from this research to develop healthy drinks for consumers.



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Abbreviations

CRD	Completely Randomized Design
RCBD	Randomized Complete Block Design
CRFD	Completely Randomized Factorial Design
ANOVA	Analysis of Variance
DMRT	Duncan's New Multiple Range Tests
DMPD	Dimethyl-4-Phenylenediamine Assay
DPPH	2, 2-Diphenyl-1-Picrylhydrazyl Assay
ABTS	2, 20-Azino-Bis [3-Ethylbenzothiazoline-6- Sulphonic Acid]
FRAP	Ferric Ion Reducing Antioxidant Power Assay
CuPRAC	Cupric Reducing Antioxidant Capacity Assay

Introduction

Many different kinds of health beverages are currently being manufactured and sold in large quantities. Because they taste great, are affordable and are simple to eat, they are highly favored by customers. The product comes in powdered and ready-to-drink varieties.¹

Cocoa is a beverage product made from cocoa beans, which is a popular and widely known beverage consumed in both hot and cold forms. Cocoa also contains important substances that are beneficial to the body, such as strengthening the heart, reducing stress, and nourishing the skin. The cocoa that is currently consumed is made from fermented and roasted cocoa beans. The benefits of cocoa include antioxidants, similar to tea or red wine, but cocoa contains many more antioxidants than tea or red wine. It helps prevent many diseases and provides warmth to the body. Cocoa contains 4 times less fat than chocolate and is rich in calcium, magnesium, sodium, flavonoids and antioxidants. According to scientific evidence, drinking cocoa improves blood circulation in the brain when compared to a group that did not drink it. Cocoa has the ability to reduce the risk of blood clots, which is a cause of heart disease. According to scientific evidence, it helps to prolong life because polyphenols help flush toxins from the body. Although cocoa is used as an ingredient in many types of food, such as chocolate, eating cocoa to benefit the body should be done directly to get the full benefits. Drinking one glass of hot cocoa per day or cold cocoa is fine, but you should not add milk because milk may affect the taste of the resulting drink or add too much sugar. After all, it can be harmful to the body and should be controlled in appropriate amounts.² The fruit of plants of the

genus *Capsicum*, which belongs to the Solanaceae family, is the chili pepper (*Capsicum annuum* L.). Mexico and Central America are the origins of this crop. These days, chili peppers are grown all over the world and are utilized in a variety of dishes. In light of climate change, chili peppers are important for their production ability, heat tolerance, and effective nutrient utilization as spices and in pharmaceuticals for the extraction of bioactive substances, called capsaicinoids. Proteins, carbohydrates, amino acids, vitamins, phytochemicals, antioxidants and minerals are among the many healthy substances found in chili pepper fruits.³

At present, there are many health beverages on the market, such as weight-loss coffee, which is popular among consumers. Further, there is high competition in the market. Cocoa is one type of drink that is increasingly popular, so the idea was to produce a drink with a unique taste that is beneficial to consumers by choosing to mix it with chili powder and produce a drink made from cocoa drink mixed with chili powder in a ready-to-use powder form. Because chili is an economical crop in Thailand, chili powder is an economically and industrially important product. It can easily be found in all seasons.^{1,2} Capsaicin, a compound found in chili peppers, plays a major role in the body through various physical and chemical reactions, such as reducing pain, stimulating digestion, reducing the risk of heart disease and improving blood circulation. In cocoa drinks with chili peppers, capsaicin may enhance the flavor and stimulate fat burning. The role of compounds in chili on the body such as capsaicin. The important spicy substance in chili has the effect of relieving pain, reducing inflammation and stimulating blood circulation. Chili contains vitamins

A, C and various minerals that help strengthen the immune system, nourish the eyes and help the body function. Chili contains antioxidants that help slow down cell degeneration, reduce the risk of cancer and lower the risk of heart disease. Beta-carotene is a yellow-orange substance in chili that helps strengthen the immune system and nourish the eyes. The role of cocoa drinks with chili such as taste. Capsaicin in chili may help enhance the taste of cocoa by making it more intense. Metabolism. Capsaicin may help stimulate the burning of fat in the body. Cocoa also contains antioxidants that help fight free radicals and promote health. Cocoa contains various vitamins and minerals that help nourish the body.³

Chili powder has the highest amount of capsaicin, has a spicy property, and has various properties that are beneficial to the body, such as helping to burn fat, lose weight, and help with blood circulation as well as many other benefits.³ Eating chili can help you lose weight because capsaicin in chili contains thermogenic substances, which are substances that create heat in the body. This positively affects the metabolic system and stimulates metabolism, helping us lose weight faster. In addition, chili also contains ascorbic acid, which helps the body convert fat into energy.³ Five connected research projects focused on related products. Primarily, this study sought to determine how panelists' approval of chocolate beverages made with low-fat cocoa powder was impacted by hydrocolloids (iota, kappa and xanthan gum). Also assessed were the effects of hydrocolloid incorporation on the color, total soluble solids and pH level of the chocolate beverage. The outcome demonstrated that adding hydrocolloids raised the panelists' acceptability rating. The maximum degree of panelist approval was obtained with a 0.2% addition of xanthan gum. While there was very little color variation between the chocolate beverage with and without hydrocolloids, there was a substantial difference between the pH value and total soluble solids of the hydrocolloid-containing chocolate beverage and the control.⁴ Next, this study used a 30:70 (w/w) ratio of cocoa powder to sugar to spray-dry a chocolate beverage formulation (the full recipe is given and protected). To create a liquid feed, 17.5 g of powder was dissolved in 100 mL of deionized water at 60°C, which was then thoroughly mixed. A little spray drier was fed into the fluid. A temperature of 150°C was employed as the inlet

for this investigation. The drying airflow rate (22, 27 and 32 m³/h) and maltodextrin concentration (0.0, 3.5 and 7.0% w/w) were changed. Before analysis, the powders were stored in closed, dark jars at 4°C. With a drying air flow rate of 27 m³/h and a maltodextrin concentration of 3.5% w/w, the full factorial design produced a powder with a solubility of 74.2 ± 6.8% and a dispersibility of 58.7 ± 2.9%. The powder recovery yield at this operating condition was nearly identical to the industrial one (45.5 ± 2.5%).⁵ The next purpose of this study was to examine how the inclusion of xanthan gum and torch ginger, also known as kecombrang (*Etilingera elatior*), affected the physical characteristics, antioxidant activity and sensory aspects of cocoa drinks. The addition of powder from the torch ginger flower raised the cocoa drink's antioxidant activity while lowering its pH and decreasing consumers' enjoyment of its flavor and scent. When 0.09 g of xanthan gum was added, the overall solubility of the cocoa drink increased and its sedimentation decreased.⁶ Next, using CRFD, this study examined how the concentration of ginger powder (0-8%) and the fat content of cocoa powder (both low and high) affected the stability and characteristics of ready-to-drink cocoa beverages. To provide information on the crucial factors in the cocoa drink, a poll was also conducted to uncover what consumers thought about the attributes and qualities of the beverage. The findings indicated that the two most crucial factors influencing the acceptance of cocoa beverages were viscosity and sedimentation. The amount of fat in the raw material had a major impact on the stability of the ginger-flavored cocoa beverage. The sample made with 8% ginger powder and low-fat cocoa powder was the most popular cocoa beverage. The sample had a total phenolic content of 9.53 mg GAE/mL, a viscosity of 18.53 cP and pH of 7.68, cocoa beverage, a lightness level of 29.21, a total flavonoid content of 4.68 mg QE/mL cocoa beverage and an antioxidant activity of 70.5%.⁷ Lastly, studied factors influencing consumer acceptability of hot cocoa-based beverages prepared with pure cocoa powders. Five samples were chosen, including standard and fat-reduced cocoa powders, as well as alkalized and non-alkalized (natural) cocoa powders. 116 people in total participated in the sensory evaluation of the samples using a 5-point just-about-right scale and a 9-point hedonic scale. The association between acceptability and fat content, phenolic composition and alkalization was brought

to light by Principal Component Analysis. Regular cocoa powders outperformed low-fat samples in terms of color (6.6 and 5.8), smell (6.3 and 5.4), flavor (5.9 and 4.8), texture (6.2 and 5.6), and overall (6.1 and 5.1), while alkalized samples outperformed natural ones in terms of color (6.9 and 5.6), smell (5.9 and 5.7), flavor (5.8 and 4.9), texture (6.0 and 5.7), and overall (6.0 and 5.2). Consumer preference was lowered when the phenolic content exceeded 30 g GAE/kg d.w.⁸

A quick scan of the literature as presented reveals that, although earlier research looked at the drying process concerning certain fruits and vegetables, no study has addressed the topic of hot-air oven drying mixtures for chili and cocoa drinks. Therefore, the researchers are interested in developing low-fat cocoa drinks mixed with chili powder that help burn fat, making instant cocoa drinks mixed with chili powder a new alternative drink that can reduce obesity for consumers who do not drink coffee. According to Halib *et al.*,⁹ the main components of cocoa polyphenols are flavonols (quercetin) and flavanols (epicatechin, catechin and procyanidins). Small amounts of other polyphenols, including anthocyanins, phenolic acids and stilbenes, have also been reported. Adipocytes are a subset of cells that specialize in storing fat and are essential for metabolic control, according to Wang *et al.* (2010).¹⁰ Triglycerides are stored and mobilized by white adipocytes, which also secrete a variety of lipid and protein molecules that regulate energy balance. Obesity may result from excessive white adipocyte growth and hyperplasia (adipogenesis). On the other hand, obesity is linked to a lack of brown and beige fat, and metabolic health benefits from the reactivation of brown and beige fat to control systemic energy levels. The most popular plant-based beverage in the world is cocoa, which has been thoroughly studied for possible anti-obesity ingredients and shown to have a number of bioactive components. There isn't yet a thorough analysis that outlines the molecular underpinnings behind cocoa beverages' potential to prevent obesity.

In addition, the drink also contains antioxidants, vitamins and other nutrients. It has the potential to broaden the consumer base. The goal of this study was to investigate the appropriate percentage of chili

powder for producing cocoa powder drinks mixed with chili powder and to study the physicochemical, microbiological and sensory properties of cocoa powder drinks mixed with chili powder.

Materials and Methods

The raw materials used in this study were white sugar, milk powder, chili powder and cocoa powder, which were purchased from the Makro Rangsit store in Thailand's Pathum Thani Province and brought to the lab. Analytical-grade chemicals and food-grade chemicals with a 99.8% purity that could be used in food products were used in the investigation.

Raw Material Preparation

The main raw materials for this research are 2 types: chili and cocoa. The secondary raw materials are white sugar and milk powder.

Chili Preparation

Red garden chilies were sorted into the rotten and green parts by hand, washed with clean water, and then set aside until the water boiled. The parts were then blanched in boiling water at 100°C for about 1-2 min. Immediately, the chilies were soaked in cold water or room temperature water, scooped out of the cold water and then drained of water. The chilies were placed in a tray and then placed into a tray-type hot-air drier at a temperature of 55-60°C for 16-18 h until completely dry. The samples were then ground with an electric blender and sifted with a 120-mesh sieve. Subsequently, the obtained samples were mixed according to the ratios for each treatment, as shown in Table 1.¹¹

Milk Preparation

Fresh milk was measured to 200 mL and weighed with the amount of egg white powder. The fresh milk was heated at 72°C for 15 s. After that, the milk temperature was lowered to 30°C or room temperature. The milk was poured into a mixer, after which the milk foam was scraped from the tray and blended with an electric blender until it was finely ground into a powder. Gradually, 3 g of egg white powder (beaten at speed level 1) was added and continued to beat at speed level 4 until foam formed. The foam was scooped onto an aluminum tray with a thickness of about 2 to 3 mm for 90 min and then baked in a hot air oven at 70°C. The milk foam was

removed from the tray, and an electric blender was used to grind it into powdered form. The powdered form was sifted through a sieve with a diameter of

120 mesh and mixed according to the ratios for each treatment.¹²

Table 1: Ingredient composition for a combination of chili and cocoa powder

Ingredient (%)	powdered chili 0.0%	powdered chili 0.1%	powdered chili 0.2%	powdered chili 0.3%
Refined chili	0.00	0.10	0.20	0.30
Cocoa powder	16.67	16.61	16.56	16.50
White sugar	40.00	39.87	39.73	39.60
Milk powder	43.33	43.19	43.05	42.91

N.B. Treatment 1 is a control for the experiment without chili added in order to compare the difference between other treatments with different amounts of chili added on the physical, chemical, microbiological and sensory analysis values.

Table 2: Physicochemical properties of chili powder

Attributes	Value \pm S.D.
<i>L</i> *	41.31 \pm 0.93
<i>+a</i> *	39.32 \pm 1.12
<i>+b</i> *	65.95 \pm 0.53
Moisture (%)	1.48 \pm 0.97

properties of the powdered beverage.¹³ In addition, water solubility (AOAC 931.04)¹⁴ pH (AOAC 973.41)¹⁴ total soluble solids (AOAC 932.12)¹⁴ total acidity (%) (AOAC 942.15)¹⁴ moisture (AOAC 931.04)¹⁴ fat (AOAC 920.73)¹⁴ DPPH (%),¹⁵ total plate count (AOAC 972.44)¹⁴ sensory evaluation (measured using a 9-point hedonic scale)¹⁶ were evaluated and given a score.

Sample Preparation for Analysis

The preparation of each ingredient according to the treatment is shown in Table 1. The water was boiled and poured into the mixture, stirred until completely dissolved into a homogeneous mixture. The temperature was reduced to around 30°C (room temperature) for analysis of physicochemical, microbiological and sensory qualities.^{11,12}

Physicochemical, Microbiological and Sensory Evaluation Qualities of Mixed Powdered Cocoa and Chili Powder

For physical, chemical, microbiological and sensory analysis of product quality all treatment), choose the internationally accepted standard analysis method, such as the AOAC standard. The appropriate method can choose other analytical methods, modified for suitability and operation time, with the exception of some parameters.

A Mini Scan XE was used to measure the color measurement ((*L*)*, (*+a**) and (*+b**)) to examine the

Analysis of Data

The researcher choose a 95 percent confidence interval for this research, which is the most widely used confidence interval level. Instead of using an RCBD (sensory evaluation), which may be employed in experimental situations, the study focused on a CRD (physicochemical analysis). Both ANOVA and DMRT were used to assess the differences between treatments ($p \leq 0.05$). Each treatment was examined in triplicate, and the data were displayed as the actual values measured (mean \pm standard deviation). The PASW Statistics version 22 was used to calculate the data.¹⁶

Results

The results for each of the varied qualities of the various powdered cocoa, powdered chili, white sugar and milk powders are shown in Tables 2–7.

Table 3: Appearance of product characteristics of mixed powdered chili and cocoa

Chili powder (%)	Appearance	Color	Odor	Taste
0.0	few cocoa sediment	dark brown, cloudy	cocoa	sweet, creamy
0.1	few cocoa sediment	dark brown, cloudy	cocoa	sweet, creamy, hot
0.2	few cocoa sediment, chili flakes floating	dark brown with a slightly reddish tint, cloudy	cocoa	sweet, creamy, slightly spicy
0.3	few cocoa sediment, chili flakes floating	dark reddish brown, cloudy	cocoa	sweet, creamy, spicy

Table 4: L^* , $+a^*$ and $+b^*$ of mixed powdered chili and cocoa

Attributes	Chili powder (%)			
	0.0	0.1	0.2	0.3
L^*	25.62 ± 0.03 ^b	26.36 ± 0.18 ^a	27.06 ± 1.02 ^a	27.60 ± 0.17 ^a
$+a^*$	42.97 ± 0.18 ^b	43.45 ± 1.02 ^b	43.55 ± 0.39 ^{ab}	44.11 ± 0.53 ^a
$+b^*$	31.02 ± 2.34 ^b	34.29 ± 0.39 ^a	34.92 ± 2.46 ^a	37.13 ± 2.34 ^a

*(a – b) Values in the same column that are followed by the same letter do not significantly differ.

Table 5: Chemical components of mixed powdered chili and cocoa

Chemical component	Chili powder (%)			
	0.0	0.1	0.2	0.3
Moisture (%) ^{ns}	5.48 ± 1.20	4.25 ± 0.00	4.76 ± 0.04	4.10 ± 0.02
Fat (%) [*]	2.90 ± 0.12 ^a	1.97 ± 0.00 ^b	1.60 ± 0.00 ^c	1.31 ± 0.00 ^d
Total soluble solid (°Brix) ^{ns}	25.00 ± 0.20	24.67 ± 0.20	24.67 ± 0.20	24.33 ± 0.20
pH [*]	7.21 ± 0.18 ^a	7.08 ± 0.32 ^a	6.92 ± 0.20 ^b	6.85 ± 0.40 ^b
Total acidity (%) ^{ns}	0.19 ± 0.01	0.19 ± 0.10	0.19 ± 0.15	0.20 ± 0.10
Water solubility (%) [*]	7.76 ± 0.05 ^{ab}	7.85 ± 0.02 ^{ab}	7.58 ± 0.01 ^b	7.92 ± 0.02 ^a
DPPH (%) [*]	77.23 ± 1.12 ^d	79.54 ± 0.98 ^c	81.12 ± 0.65 ^b	84.33 ± 1.32 ^a

*(a – d) Values in the same column that are followed by the same letter do not significantly differ., ns indicates non significant ($p > 0.05$) in horizontal line.

Discussion

Because color affects a consumer's decision and preference, even before the product is consumed, it is a crucial criterion and the first quality feature that customers evaluate. Both look and color can be linked to sensory assessment.¹⁷ The color analysis for this research was chosen as the Hunter method because it is an internationally accepted measurement method in the food industry,

convenient and not costly. From the analysis of the physical properties of chili powder (Table 2), it was found that the Hunter method (L^* , $+a^*$ and $+b^*$) values were 41.31, 65.95 and 39.32, respectively. The $+a^*$ value was found to be high, which was consistent with Muangsi,¹⁷ who implied that, since chili is a red vegetable, lycopene in chili is a source of pigments that give yellow, orange, and red-orange colors, which affects the measurement of $+a^*$

and $+b^*$ values. Therefore, the color of the cocoa beverage will be redder and darker yellow when the amount of chili powder is increased. From the analysis of the chemical properties of chili powder, it was found that the moisture content of chili powder was low, with a value of 1.48%, because it had gone through the drying process to remove moisture from the food by hot air drying.^{18,19} This was consistent with Prasert,¹⁸ who found that some of the water retention from the food pieces evaporates during drying, thus reducing the moisture content in the food. This result showed a slower drying rate in the movement of moisture from the food to the surface. The drying rate remains constant when the amount of moisture in the food decreases until the moisture content in the food is equivalent to the amount of moisture in the air.¹⁹

From the study of instant cocoa and chili powder beverage products, ready to drink by studying the amount of chili powder mixed in the cocoa beverage, was 0.0, 0.1, 0.2 and 0.3% chili powder (Table 3). A beverage product's look has a significant impact on consumer acceptance. Sedimentation is acknowledged as a prevalent type of physical flaw in beverages.⁷ Cocoa and chili powder with a specific weight and size naturally experience sedimentation in the suspension system due to gravity.²⁰ It was found that all treatments had similar values; the appearance had a small amount of cocoa sediment and a small amount of chili residue gradually increasing with increasing amount of chili powder until the treatment with 0.3% chili powder had a dark brown color to red and easily precipitates after being heated. However, no study has been conducted on stabilizers since the amount of precipitation in each treatment is minimal.^{6,20,21} It was shown that the addition of chili powder has a positive correlation with sedimentation occurrence.⁷ In terms of the smell of the product, it will smell like cocoa. In terms of the taste of the product, it will taste spicier as the amount of chili powder increases.^{20,21} Hokawat²² said that chili has a special property, which is spiciness. The spicy taste of chili is due to capsaicin, which accumulates in the placenta of chili fruits. Chili with 1% capsaicin by weight is considered very spicy, which affects the acceptance of the product.

From Table 4, it was found that the physical characteristics of ready-to-drink chili powder cocoa beverages using different levels of chili powder

content at 4 levels, namely 0.0% (control formula), 0.1, 0.2 and 0.3% showed that the Hunter method (L^* , $+a^*$ and $+b^*$) values at 0.4% chili powder content had the highest values of 27.60, 44.11 and 37.13, respectively. It was found that the L^* , $+a^*$ and $+b^*$ tended to increase with the increasing amount of chili powder.²³ This is because lycopene in chili is a source of pigments that give yellow, orange and red-orange colors,¹⁷ which affect the $+a^*$ and $+b^*$ values. Therefore, the color of the cocoa drink will be redder and darker yellow^{6,20} when the amount of chili powder is increased and the high-temperature heating process causes a non-enzymatic browning reaction such as caramel or the Maillard reaction.^{24,25} In addition, it may be caused by the decomposition of pigments in chili.^{24,25}

For the following parameters: solubility in water, total soluble solids, total acidity (%), moisture and fat, the AOAC analysis method, which is an internationally accepted standard method, was used.

From the study of the chemical composition of instant cocoa drinks mixed with chili powder in 4 levels of chili powder content, 0.0, 0.1, 0.2 and 0.3%, there was no statistically significant difference ($p>0.05$). It was found that, with 0.0% chili powder, there was the highest moisture content, which was 5.48%. The moisture content of the product did not only depend on the chili powder content but also other ingredients, such as cocoa powder, sugar and milk powder. It was also demonstrated that the L^* , $+a^*$ and $+b^*$ values were impacted by the fat content of cocoa powder values and chili powder of the cocoa drink mixed with chili powder. The higher the chili powder amount, the lower the fat value gets. In general, the quality of the raw material affects the quality of the finished product. Regarding lipid content, the Maillard reaction is influenced by the amount of unsaturated fatty acids in cocoa butter.^{6,24,25} This is because the bioactive substance and unsaturated fatty acids in chili are broken down during the heating process to create aldehydes that contribute to the reaction.^{6,24,25} According to Arnoldi *et al.*,²⁵ fat will oxidize to produce aldehydes and ketones during the heating process. The color of fat is affected by the Maillard process, which produces melanoidin, a brown molecule, because of the reaction between fructose and amino acids.^{6,24,25}

At 0.3% chili powder, there was the lowest fat content, which was 1.31%. This was because this control formula did not add chili, which could burn fat and convert it into energy.²⁶ Therefore, the cocoa mixed with chili powder product has low fat content. From the experimental results, the fat content tends to decrease with an increase in chili powder content.²⁶

From the study of the total soluble solids, it was found that the instant cocoa drink mixed with chili powder in the form of ready-to-drink powder contained four levels of chili powder per 100 mL of water. The amounts of chili powder at 0.0, 0.1, 0.2 and 0.3% were not observed to differ substantially ($p > 0.05$), which were 25.00, 24.67, 24.67 and 24.33°Brix, respectively.⁴ It was found that the amount of total soluble solids tended to decrease with increasing amounts of chili powder. The amount of total acidity percentage did not differ significantly ($p > 0.05$), which were 0.19, 0.19, 0.19 and 0.20%, respectively. It was found that the amount of total acid tended to decrease with increasing amounts of chili powder. Chili is a good source of ascorbic acid. This substance helps expand blood vessels in the intestines and stomach to absorb food better.²² In addition to helping with flavor, acid also affects the quality of the product.²²

From the study of the water solubility of instant cocoa mixed with chili powder in the amount of chili powder at 4 levels, which were 0.0, 0.1, 0.2 and 0.3%, the difference was statistically significant ($p \leq 0.05$). The amount of chili powder at 0.0, 0.1 and 0.3% was not different, but it was different from the amount of chili powder at 0.2%. The water solubility with the amount of chili powder at 0.2% had the highest water solubility index at 7.92%, which was the result of the amount of chili powder at 0.2%, which had the lowest moisture content. Adding white sugar also increases solubility. Sugar contains hydroxyl groups that can form hydrogen bonds with water molecules, thereby increasing the solubility of cocoa drinks.²² The characteristics of the dry product with low moisture content made it dissolve well in water when dissolved in water and took a short time to dissolve, which was in line with the findings by Goula *et al.*¹⁹ When the temperature was high, the moisture content of the product was low, while high porosity resulted in better dissolution.

The chemical property investigation revealed a substantial difference ($p \leq 0.05$) between the pH and DPPH. The experimental results showed that the amount of chili powder added affected the pH and antioxidant activity. For the pH measurement of the beverage products, the measured values were in the range of 6.85-7.21. It is a low-acid food product requiring storage at low temperatures, so it spoils easily due to microorganisms.²¹ To improve shelf-life stability and lessen the alkalinity or bitter taste profiles, the pH regulators were probably added to the cocoa beverages to maintain a slightly acidic pH of 5-6.²⁷ These acidic compounds release H^+ ions when dissolved in water, forming bonds with water molecules. The more acidic the material, the more H^+ ions are released and the lower the pH.^{7,19} Furthermore, the heat treatment in pasteurization results in changes in the pH and the percentage of total acidity.^{21,27}

The antioxidant properties of chili and cocoa are important for beverage products and can be analyzed by several assays such as DMPD, DPPH, ABTS, FRAP and CuPRAC. In addition, vitamins C, E, anthocyanin and phenolic compounds in chili pepper exhibit antioxidant properties.^{6,28} In this research, the DPPH method was selected.¹ This method is an internationally accepted measurement method in the food industry, convenient, and not cost. From the analytical results, it was found that the DPPH value increased with the amount of chili powder added. The treatment with 0.3% chili powder added had the highest DPPH value of 84.33%. Since the amount of antioxidants analyzed depended on the amount of chili peppers added, the addition of chili peppers at a concentration of 0.3% was the highest and therefore had the highest antioxidant value when compared to the other treatments.^{1,28} In addition to the different values depending on the amount of chili powder added, it also depended on the variety of chili.²⁹ It has been demonstrated that certain bioactive compounds in chili possess antioxidant qualities that enable them to scavenge free and peroxide radicals, hence preventing oxidation.⁷ It has been reported that chili in the pre-ripening stage had the highest DPPH value in the range of 270-360 $\mu\text{M TE/g DM}$, while chili in other stages did not remain constant depending on the variety. Therefore, exposure to high temperatures during the heating process can trigger the Maillard

reaction, which produces intermediate compounds that can affect antioxidant activity.³⁰ The resulting intermediate compounds, such as pyrazinium and pyridinium, are reactive, so the longer the heating

time and the higher the temperature used, the more reactive compounds will be produced, reducing the antioxidant activity.²³

Table 6: Microbiological properties of mixed powdered chili and cocoa

Chili powder (%)	Values (CFU/mL)
0.0	<1x10 ²
0.1	<1x10 ²
0.2	<1x10 ²
0.3	<1x10 ²

Table 7: Sensory evaluation of mixed powdered chili and cocoa

Chili powder (%)	Liking scores			
	Color*	Odor*	Taste*	overall acceptability*
0.0	7.77 ± 0.90 ^a	7.27 ± 1.57 ^a	7.57 ± 1.27 ^a	7.83 ± 0.91 ^a
0.1	7.27 ± 1.41 ^b	6.60 ± 1.63 ^{ab}	5.70 ± 1.80 ^b	6.33 ± 1.69 ^b
0.2	7.07 ± 1.71 ^b	6.73 ± 1.51 ^{ab}	5.30 ± 2.00 ^c	5.93 ± 1.68 ^c
0.3	7.03 ± 1.61 ^b	6.93 ± 1.20 ^b	4.87 ± 1.89 ^d	5.33 ± 1.73 ^d

*(a – d) Values in the same column that are followed by the same letter do not significantly differ.

For microbial analysis, the method of bacterial count determination is chosen, which is a universally accepted standard method. From the microbiological analysis results of the four experimental products (Table 6), the number of bacteria was less than 1x10² CFU/sample. The results of the bacteria found in the cocoa product mixed with chili comply with the industrial product standard for cocoa powder for industrial use,³¹ which specifies that the total number of microorganisms in cocoa products must not exceed 3x10³ CFU/gram of sample.³¹ This indicates that all experimental beverage products were pasteurized to a temperature level that can destroy some microorganisms. However, certain microorganisms that are resistant to high temperatures can grow. GMP²¹ ensures that the production methods and processes are safe, sanitary and clean. This investigation supported the findings of Wirivutthikorn,²¹ who reported that bacteria of cocoa products less than 1,500 CFU/sample were found for cocoa powder 6% and 5.4% less than 1,200 CFU/sample were found for cocoa powder 5.7% and less than 2,400 CFU/sample were found for cocoa powder 5.1%.

The sensory analysis for this research was conducted using the 9-point hedonic scale method because the purpose of the tasting was to measure the level of product liking by the panelists. Table 7 shows the sensory evaluation of color, odor, taste and overall acceptability when comparing the fondness scores between the control formula of instant chili powder cocoa drink and the control formula of instant chili powder cocoa drink with 0.1% chili powder. Taste and general acceptability did not differ in a statistically significant way ($p > 0.05$). The sensory evaluation score of the instant chili powder cocoa drink with 0.1% chili powder was ranked second after the control formula. Therefore, adding 0.1% chili powder to the cocoa drink had the closest sensory fondness score to the control formula. Since polyphenols are carriers of astringency and bitterness, their level in cocoa is also one of the most crucial factors.²⁸ Alkaloid components like caffeine, theobromine, pyrazine, phenolics and certain peptides and amino acids give chocolate drinks their distinctively bitter flavor.³² The addition of chili powder in increasing amounts decreased the sensory liking score except for the aroma value. The panelists' approval of the

cocoa drink's texture also declined as the amount of chili powder added was increased.⁶ As chili matures, its intensity is rapidly developed on the middle and tip of the tongue, lasting incredibly long and producing sensations quickly. This can be because there are a lot of bioactive substances present. A variety of chili peppers are attributed to their genetics, cultivar, cultivation methods, fruit maturity and environmental conditions (differentiation of the total heat level of chili peppers).^{33,34} However, the addition of chili powder increases the nutritional value of the beverage according to the increased amount of chili powder. Chili is a source of ascorbic acid in the form of vitamin C and capsaicin in chili has the ability to burn and convert body fat into energy.^{3,17} In addition, there is a chemical reaction due to the heating process causing a non-enzymatic browning reaction in cocoa.^{21,24} From the research results, it was observed that the addition of chili in an amount greater than 0.1% resulted in a decrease in product acceptance. In future studies, the amount of chili may need to be reduced, which should make consumers more accepting of the product because the panelists may not be familiar with the spiciness of chili.

Conclusion

The results of the investigation showed the appropriate amount of chili powder and the acceptance by consumers in the production of instant cocoa beverages mixed with chili powder from the production of instant cocoa beverage using 4 levels of chili powder, namely 0.0% (control formula) 0.1, 0.2 and 0.3%. It was found that 0.0% chili powder, or the control formula, had the highest sensory test scores and consumers accepted cocoa beverages with 0.0% chili powder or the control formula more than beverages mixed with chili powder, namely 0.1, 0.2 and 0.3%. From the sensory test, the amount of chili powder of 0.1% was the amount of chili powder that was second only to the control formula in the production of instant cocoa beverages. For next research suggestions, methods to reduce the pungent smell of chili powder should be studied to develop products with better smell and taste, such as adding synthetic cocoa flavor to ready-to-drink cocoa mixed with chili powder.

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Conflict of Interest

The author does not have any conflict of interest.

Data Availability Statement

This manuscript incorporates all datasets examined throughout this research study.

Ethics Statement

This research did not involve human participants, animal subjects or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials.

Permission to Reproduce Material from Other Sources

Not applicable.

Authors Contributions

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing and final approval of the manuscript.

References

1. Wirivutthikorn W. Effects of Stevia Syrup on Powdered Drink Products from Pumpkin Carrot and Lemongrass by Foam Mat Drying. *Curr Res Nutr Food Sci Jour.* 2025;13(1):405-416. DOI: <https://dx.doi.org/10.12944/CRNFSJ.13.1.27>
2. Afoakwa E. O. Cocoa Production and Processing Technology. CRC Press Taylor & Francis Group Taylor & Francis Group. *Boca Raton*; 2014.
3. Olatunji T. L, Afolayan A. J. The Suitability of Chili Pepper (*Capsicum annum* L.) for Alleviating Human Micronutrient Dietary Deficiencies: A Review. *Food Sci and Nutr Jour.* 2018;6:2239-2251. DOI: <https://10.1002/fsn3.790>
4. Aribah S. A., Sanjaya A. P., Muhammad D. R. A., *et al.* Sensorial and Physical Properties of Chocolate Beverage Prepared Using Low Fat Cocoa Powder. Paper Presented at The 2nd International Conference and Exhibition on Powder Technology (ICePTi); 20–21 August 2019; Solo, Indonesia. <https://pubs.aip.org/aip/acp/article/2219/1/070007/770105/Sensorial-and-physical-properties-of-chocolate>. Accessed date 13 January 2023.
5. Aliakbarian B., Casazza A. A., Nani A., *et al.* Production of Chocolate Powdered Beverage with Enhanced Instant Properties. *Chem Eng Trans Jour.* 2017;57:877-882. DOI: <https://10.3303/CET1757147>
6. Pamungkaningtyas F. H., Leonardi R. Investigation of Physical Properties, Antioxidant Activity and Sensory Attributes of Cocoa Drink with the Addition of Torch Ginger Flower (*Etilingera elatior*) and Xanthan Gum. Paper Presented at The 5th International Conference on Natural Resources and Technology; 29 August 2023; Medan, Indonesia. <https://iopscience.iop.org/article/10.1088/17551315/1352/1/012083>.
7. Faiqoh K. E. N., Muhammad D. R. A., Praseptiangga D. Ginger-Flavoured Ready-to-Drink Cocoa Beverage Formulated with High and Low Fat Content Powder: Consumer Preference, Properties and Stability. *Food Res Jour.* 2021;5(Suppl.2):07-17. DOI: [https://doi.org/10.26656/fr.2017.5\(S2\).004](https://doi.org/10.26656/fr.2017.5(S2).004)
8. Palma-Morales M., Birke Rune C. J., Castilla-Ortega E., *et al.* Factors Affecting Consumer Perception and Acceptability of Chocolate Beverages. *LWT - Food Sci and Tech Jour.* 2024;201:01-10. DOI: <https://doi.org/10.1016/j.lwt.2024.116257>
9. Halib H., Ismail A., Mohd Yusof B. N., *et al.* Effects of Cocoa Polyphenols and Dark Chocolate on Obese Adults: A Scoping Review. *Nutr Jour.* 2020;12(3695):01-19. DOI:10.3390/nu12123695
10. Wang Q., Hu G. L., Qiu M. H., *et al.* Coffee, Tea and Cocoa in Obesity Prevention: Mechanisms of Action and Future Prospects. *Curr Res in Food Sci Jour.* 2024;8:01- 20. DOI: <https://doi.org/10.1016/j.crfs.2024.100741>
11. Purika S., Aunaudomvana N., Panyoyai N. Pretreatment Techniques of Dehydrated Red Spur Chili Peppers for Compliant Thai Agricultural and Community Food Standards. *Sci and Tech to Com Jour.* 2023;1(4):01-18. DOI: <https://doi.org/10.57260/stc.2023.543>
12. Kongsanant S., Dam-eam R., Srirungrueang L., *et al.* Product Development of High-Protein Red Bean Milk. *Pbru Sci Jour.* 2023;20(2):92-101.
13. Muhammad D. R. A., Saputro A. D., Rottiers H., *et al.* Physicochemical Properties and Antioxidant Activities of Chocolates Enriched with Engineered Cinnamon Nanoparticles. *Euro Food Res and Tech Jour.* 2018;244: 1185-1202. DOI: <https://doi.org/10.1007/s00217-018-3035-2>
14. AOAC. Official Methods of Analysis. 15th ed. The Association of Official Analytical Chemists (AOAC), Washington, D.C.; 1990.
15. Burguieres E., McCue P., Kwon Y. I., *et al.* Effect of Vitamin C and Folic Acid on Seed Vigour Response and Phenolic Linked Antioxidant Activity. *Biore Tech Jour.* 2007;98(7):1393-1404. DOI: <https://doi.org/10.1016/j.biortech.2006.05.046>
16. Wiriyajari P. Sensory Evaluation. Department of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University. Chiang Mai; 2018.
17. Muangsi W. Horticultural Characteristics and Lycopene Levels of Tomato Varieties. Degree

- of Agricultural Technology. King Mongkut's Institute of Technology North Bangkok. Bangkok; 2004.
18. Prasert W. Techniques of Foam Mat Drying. *Food Jour.* 2013;43(3):23-26.
 19. Goula A. M., Karapantsios T. D., Achilias D. S., *et al.* Water Sorption Isotherms and Glass Transition Temperature of Spray Dried Tomato Pulp. *Food Eng Jour.* 2008;85(1):73-83. DOI: <https://doi.org/10.1016/j.jfoodeng.2007.07.015>
 20. Nurhayat R., Laila U., Herawati E. R. N., *et al.* The Developing of Reduced-Sugar Ready-to-Drink Cocoa Beverages: Optimization of Stabilizers and Sugar Replacers Concentration. *Food Sci Tech Campinas Jour.* 2023;43(e107322):01-09. DOI: <https://doi.org/10.1590/fst.107322>
 21. Wirivutthikorn W. Product Development of Mixed Cocoa Powder and Gotu Kola Powder Beverage. Poster Presented at The 11th Phayao Research Conference Theme: Economic and Social Recovery from Covid-19 by Research and Innovation; 25-28 January 2022; Phayao University, Phayao, Thailand. <http://22Aprilwww.prc.up.ac.th/PDF-Flip/Proceedings.html>
 22. Hokawat S. Disease of Pepper and Tomato. Khon Jaen University. Khon Kaen; 1993.
 23. Indiaro R., Herwanto J. A., Filianty F., *et al.* Total Phenolic and Flavonoid Content, Antioxidant Activity and Characteristics of a Chocolate Beverage Incorporated with Encapsulated Clove Bud Extract. *CyTA-Food Jour.* 2024;22(1):01-05. DOI: <https://doi.org/10.1080/19476337.2024.2329144>
 24. Martinez M. V., Whitaker J. R. The Biochemistry and Control of Enzymatic Browning. *Trends in Food Sci and Tech Jour.* 1995;6(6):195-200.
 25. Arnoldi A., Arnoldi C., Baldi O., *et al.* Flavor Components in the Maillard Reaction of Different Amino Acids with Fructose in Cocoa Butter-Water: Qualitative and Quantitative Analysis of Pyrazines. *Agric and Food Chem Jour.* 1988;36(5):988-992. DOI: <https://doi.org/10.1021/jf00083a021>
 26. Yusuf A. B., Muhammad I. M. Nutritional, Functional and Sensory Attributes of Ready-to-Use Cocoa Beverage. *Sch Int Biochem Jour.* 2023;6(1):01-07. DOI <https://doi.org/10.36348/sijb.2023.v06i01.001>
 27. Ling L., Loong C., Loke W. M. Food Additives in Commercial Cocoa Beverage Products and their Effects on Total Polyphenol Contents, Cellular Antioxidant and Anti-Inflammatory Activities. *Curr Res Nutr Food Sci Jour.* 2021;9(1):20-30. DOI: <https://doi.org/10.12944/CRNFSJ.9.1.03>
 28. Bal S., Sharangi A. B., Upadhyay T. K., *et al.* Biomedical and Antioxidant Potentialities in Chili: Perspectives and Way Forward. *Mole Jour.* 2022;27(6380):01-29 DOI: <https://doi.org/10.3390/molecules27196380>
 29. Hardiyanti R., Sari A. R., Norsita D. I., *et al.* The Effect of Garam Masala Levels Addition on Chocolate Based Functional Beverage. *Appl Food Tech Jour.* 2020;7(1):05–08. DOI: <https://doi.org/10.17728/jaft.7132>
 30. Akhter M. J., Akhter S., Islam S., *et al.* Varietal Influence on Bioactive Compounds and Antioxidant Activity in Chilies during Development Stages. *Heliy Jour.* 2024;10(e37406):01-13. DOI: <https://doi.org/10.1016/j.heliyon.2024.e37406>
 31. Thai Industrial Standards Institute Ministry of Industry. Industrial Product Standards for Cocoa Powder for Industrial Use (TIS 1137-2007). Bangkok; 2007.
 32. Cempaka L., Rahmawati E. A., Ardiansyah., *et al.* Sensory Profiles of Chocolate Drinks Made from Commercial Fermented Cocoa Powder and Unfermented Cocoa Beans. *Curr Res Nutr Food Sci Jour.* 2021;9(3):988-999. DOI: <http://dx.doi.org/10.12944/CRNFSJ.9.3.26>
 33. Cempaka L., Abdul Hakim T. E., David W. Consumer Acceptance on Chocolate Drink Made with a Mixture of Commercial Cocoa Powder and Unfermented Cocoa Powder. *Pelita Perkebunan Jour.* 2021;37(2):126-136. DOI: <https://doi.org/10.22302/iccricri.jur.pelitaperkebunan.v37i2.479>
 34. Barišić V., Icyer N. C., Akyil S., *et al.* Cocoa Based Beverages – Composition, Nutritional Value, Processing, Quality Problems and New Perspectives. *Trends in Food Sci and Tech Jour.* 2023;132:65-75. DOI: <https://doi.org/10.1016/j.tifs.2022.12.011>